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UNIT

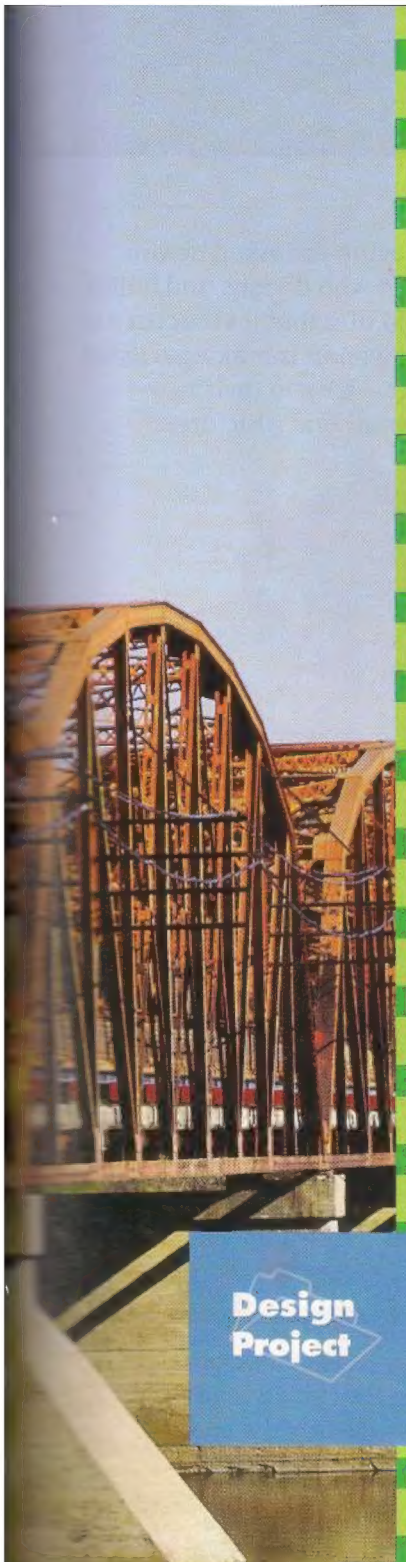
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Structures and Materials

BIG IDEAS

In this unit, you will learn that:

- structures have jobs
- humans often build structures shaped like structures found in nature
- materials make structures strong
- shape makes structures strong and stable
- First Nations and Métis peoples value materials from Mother Earth



Structures are all around you. Your school building is a structure. Saskatchewan's Outlook Bridge, shown here, is a structure. A spiderweb is one of nature's structures.

Structures need to be strong. This means they need to be made of materials that help them keep their shape. Structures also need to be stable. This means they must be steady and not fall over. In this unit, you will learn about structures and what makes them strong and stable.

Looking Forward

Have you ever built a house of cards? Here is your chance to try.

1. Place two cards 4 or 5 cm apart. Lean them into each other, so they form an upside-down V shape.
2. Make a row of shapes like that.
3. Place cards on top of the row to connect the shapes. Try building a second floor. What shapes stand up best without falling? Experiment and record your findings.

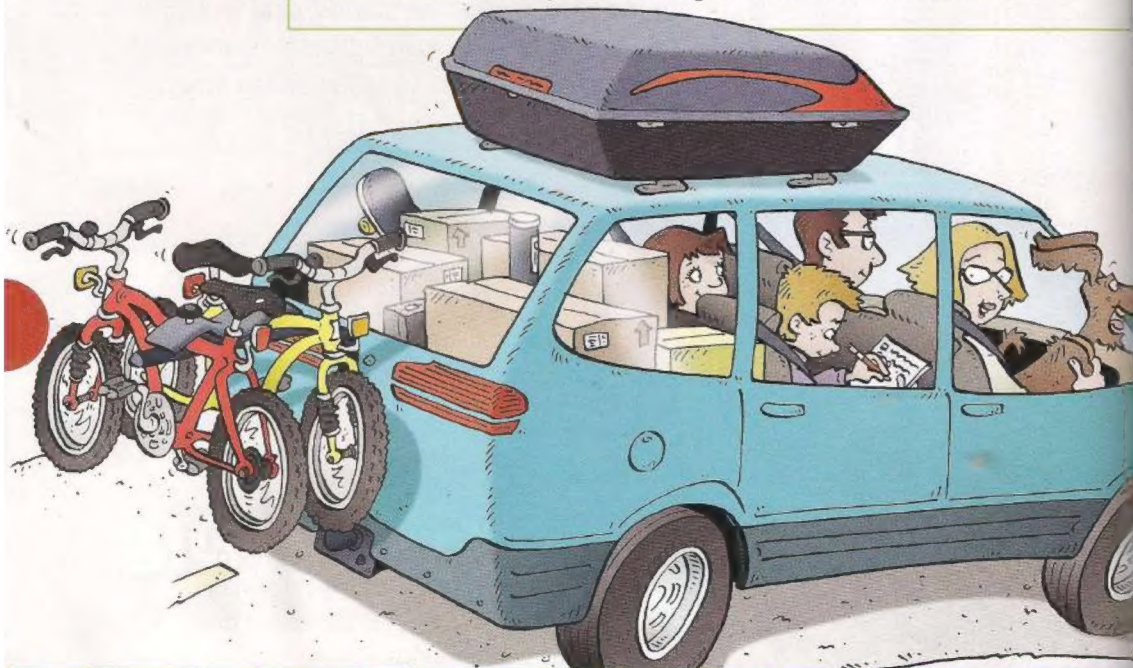
Design Project

At the end of this unit, you will complete a design project. You will build a bridge. The *Build On What You Know* activities found in the unit will help you with your project.

Finding Structures

Get Started ►

Keenan and his family are moving to Saskatchewan. Keenan's mother is an engineer who designs and builds bridges and roads. She has told him that a **structure** is something that holds weight. Keenan is making a list of all the structures they see on the drive to their new home. See if you can help Keenan find structures.



Work On It



- 1 List all the structures that you see in the picture.
- 2 In what ways are the structures the same? Record your answer.
- 3 In what ways are the structures different? Record your answer.

- 4 Name one structure built by humans and one found in nature.

Communicate



1. Write three questions about structures that you would like to have answered by the end of this unit.



Copying Nature

Goal To find and identify shapes in structures

Get Started ▶

Structures carry out jobs. A building provides people with shelter. A bridge helps people cross water. A spiderweb helps a spider catch insects to eat.

Structures found in nature are made of materials and shapes best suited for the job. A spider makes a web with silk. Spider silk is strong and elastic. It can stretch a lot and snap back into shape without breaking, like a rubber band.

Sometimes we use shapes found in nature's structures to build our own structures. Aboriginal peoples are very close to nature. They learn from nature and use that knowledge to survive. They have built homes shaped like those they saw in nature. Look at the photos below. What shapes do you see?



▲ Spider silk is strong and elastic. This helps a web hold its shape.



▲ A bird's nest is a natural structure shaped like a circle.



▲ The traditional home of the Inuit is an igloo shaped like a circle.

Work On It



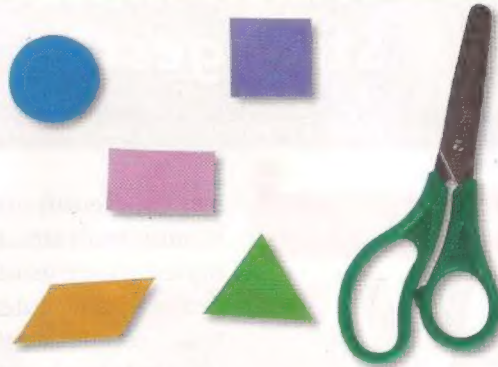
What shapes can you find in natural and human-built structures?

What You Need

- shape pictures
- scissors

What You Will Do

- 1 Use the scissors to cut out the shape pictures.
- 2 Look at the shapes. Which do you think are found in natural structures? Which in human-built structures? Record your predictions.
- 3 Look at the picture of the playground. Compare the shapes you cut out to the shapes found in the structures in the picture.
- 4 List two natural structures and two human-built ones found in the picture. Describe their shape.
- 5 Count the number of each shape that you find in the picture.



SAFETY CAUTION!

Remember to work safely when using scissors.



Communicate

1. Which shape did you find the most?
2. Which shape did you find the second most?
3. Which shape did you find the most in human-built structures? Share your findings with classmates.

Which Material Is the Strongest?

Goal To investigate the strength of materials

Get Started ▶

Some materials are better for building natural and human-built structures than others. The best building materials are usually strong, long lasting, and not too heavy. What materials are used to build an office tower, a tipi, and the chair you are sitting on? Look at the photos below and your chair to find out.



Regina's twin towers are made of concrete and steel. Concrete and steel are strong, long lasting, and withstand wind, rain, and snow.



Tipis are made to withstand the weather. Materials, such as animal hide or canvas, vary, depending on what is available in the environment. Tipi poles are made of strong, flexible trees.

You have learned that a structure is something that holds weight. The weight that a structure supports is called a **load**. The bridge you saw on page 44 supports the weight of cars and trucks. It is made of steel. Building structures with strong materials, such as steel, concrete, and wood, helps them hold loads.

Work On It



How can you test the strength of different materials?
One way is to test which can hold the most weight.

What You Need

- materials to test, such as tape, modelling clay, straws, toothpicks, string, wooden blocks, cloth, spaghetti
- small paper cup
- ruler
- scissors
- pennies or marbles (for weight)
- string

What You Will Do

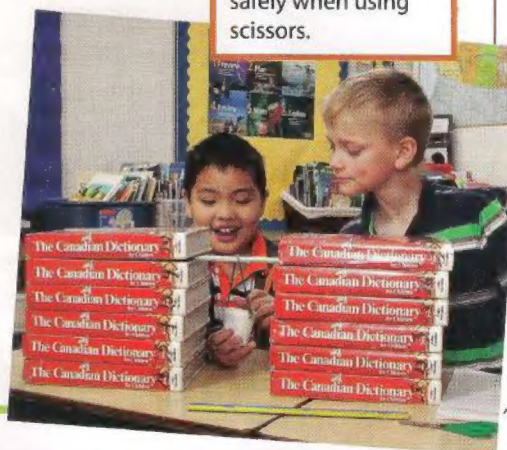
- 1 Which material do you think will hold the most weight? Record your prediction.
- 2 How do you plan to test which material will hold the most weight? Record the steps of your plan.
- 3 What other materials will you need? Make a list.
- 4 Ask your teacher to approve your plan and list of materials.
- 5 Carry out your test and record your results in a table like the one below.

Material	Most Weight Held



SAFETY CAUTION!

Remember to work safely when using scissors.



Communicate

1. Do you think the materials you tested would work to build an office tower, a bridge, or a tipi? Use the results of your investigation to help you decide.
2. Discuss your results with others in your class. How are the results the same? How are they different?
3. How did others test the materials?

Which Shape Is the Strongest?

Goal To investigate the strength of shapes

Get Started ►

The shape of a natural or human-built structure can help it resist forces, such as wind, earthquakes, or waves of water. Its shape can make it both strong and stable. Look at the pictures of shapes below. Which shapes do you think can help make a structure strong and stable?



circle



triangle



square



rectangle



pentagon



rhombus



parallelogram



hexagon



octagon

Work On It



Think about the shapes you know. Which one do you think will be the strongest?

What You Need

- Bristol board strips (10 cm by 2 cm)
- paper punch
- paper fasteners
- scissors



What You Will Do



- 1 Think of a square and a triangle. Which one do you think is the strongest? Record your answer.
- 2 Prepare the Bristol board strips as in the photo.
- 3 Make two-dimensional shapes of a square and a triangle with the Bristol board strips and paper fasteners.
- 4 Test for strength by pushing on the corners of the Bristol board shapes. Draw each shape after testing.

Communicate



1. Which shape did you find was the strongest?
2. Some human-built structures are modelled on shapes found in nature. How are the shapes that you made like shapes in nature?
3. Compare your results with others in your class. How are your results the same? Different?

Build On What You Know

How can you use square and triangle shapes in the bridge that you will build? Sketch your ideas.

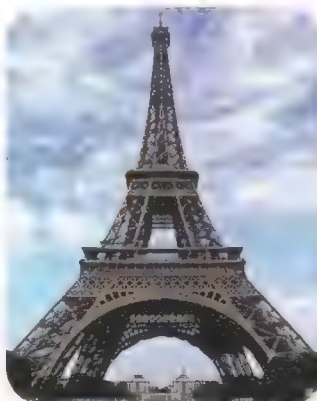
How Can We Strengthen Structures?

Goal To investigate ways to strengthen structures

Get Started

Engineers use triangles to make structures strong. Look at the photos below and find triangles in them. Why do you think the builders of these structures used triangles?

Where can you find triangles in this bridge, tower, and jungle gym?

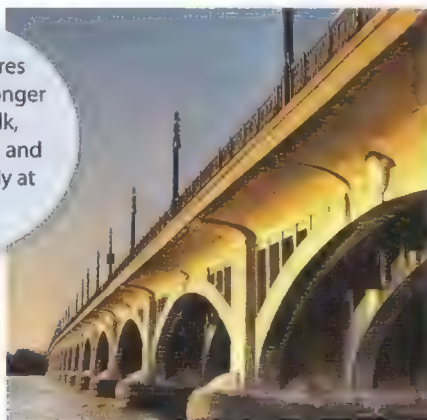


Work On It



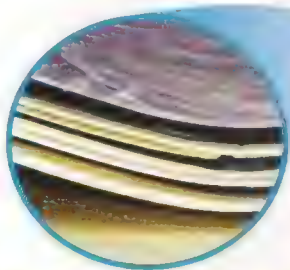
Triangle shapes can make structures stronger. There are also other ways to strengthen structures.

Some structures are made stronger by adding bulk, such as width and weight, usually at their base.



Structures, such as this skateboard, are made stronger because of the layers of material used when they are made.

Look at the structures in the photos here and on the opposite page. Discuss how these structures have been strengthened.



Communicate

Look around your classroom or playground at structures you see.

1. Can you find structures that have been strengthened by adding bulk? List them.
2. Can you find structures that have been strengthened with triangles? List them.
3. Can you find structures that have been strengthened by adding layers? List them.
4. Discuss structures you see on the way to school that have been strengthened in ways you have learned about.

Build On What You Know

Look at the square and triangle that you made in Lesson 3. How can you strengthen them to build a bridge? Find ways to use other strips of paper to make them stronger.

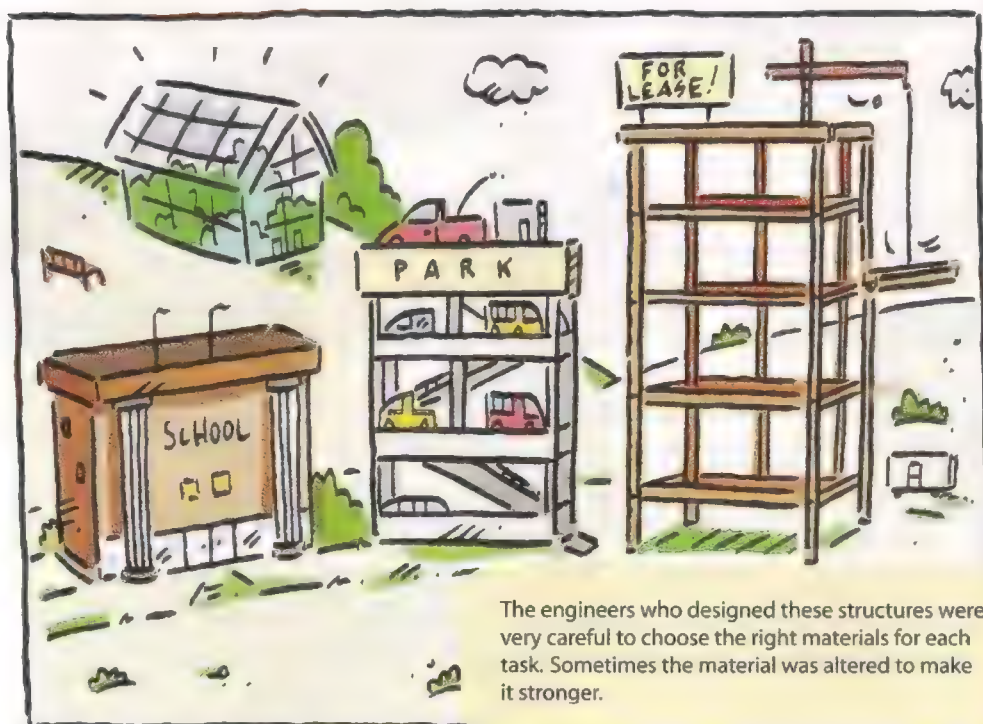
5

Making Paper Towers Strong

Goal To design and build a strong tower

Get Started ▶

You have learned that a structure is built with strong materials to hold a load. Sometimes materials are strong enough to hold loads by themselves. Other times, materials need to be changed to become stronger. We alter, or change, materials or their shapes to help them do a better job.



The engineers who designed these structures were very careful to choose the right materials for each task. Sometimes the material was altered to make it stronger.

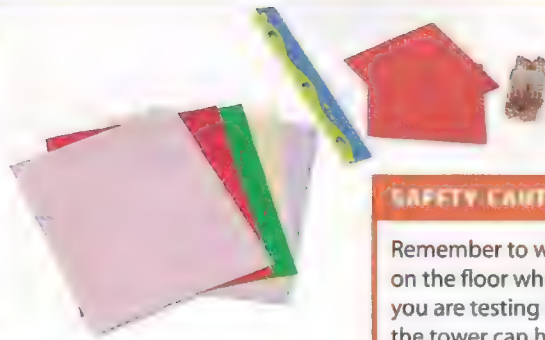
WORKING TOGETHER



With only one piece of paper and two pieces of cardboard, you can change a material to make a structure stronger.

What You Need

- photocopy paper (1 sheet for each test)
- ruler
- 2 cardboard squares (15 cm by 15 cm)
- rolls of pennies to use as loads



SAFETY CAUTION!

Remember to work on the floor when you are testing if the tower can hold the pennies.

What You Will Do

- 1 Fold one sheet of paper to make a tower 21.5 cm high.
- 2 Stand the tower upright on one cardboard square.
- 3 Draw what your tower looks like.
- 4 Set the second cardboard square on top of the tower.
- 5 Lower a roll of pennies slowly onto the top of the second cardboard square. How many rolls can it hold?
- 6 Record your results.
- 7 Fold other sheets of paper differently to make other towers. Draw a picture of each tower holding the pennies.



Communicate

1. Which towers held the most pennies?
2. How stable and well balanced were these towers? Explain your answer to a partner.
3. Sketch a diagram of the tower that was the most stable and balanced.
4. Describe how you altered the paper that you used to make your strongest tower.

Nature's Balancing Act

Goal To explore how shape helps humans and animals balance and stay stable

Get Started ▶

You stand and walk on your feet. As your feet touch the ground, they help you balance and stay stable. Your feet are points of contact with the ground. Other animals also have points that touch the ground.



Kangaroos have three points that touch the ground—two feet and a large tail.



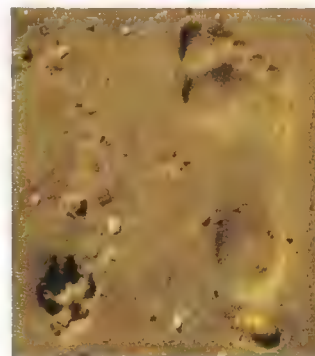
Coyotes have four points that touch the ground.

You have learned that the strongest shape is a triangle. A triangle is also the most stable shape. A stand that holds a camera steady is shaped like a triangle. It has three points of contact with the ground. But humans can stay stable on just one or two points. Your feet contact the ground over a large area. This spreads out your weight for support.



▶ This camera stand has three points that touch the ground.

▶ Human feet contact the ground over a larger area than dog feet.



Work On It



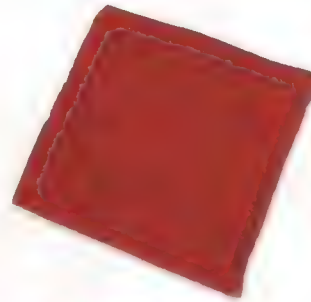
Can you run like a dog, walk like a penguin, or hop like a rabbit? Here is your chance to try. An animal is most balanced when its weight is spread evenly among its points that touch the ground. An animal's balance point is in the middle of its points that touch the ground.

What You Need

- large open area
- beanbag or small pillow

What You Will Do

- 1 Follow instructions to walk like different animals.
- 2 For each animal, place the beanbag on your body where you think the animal's balance point is. Then try to walk like the animal without dropping the beanbag.
- 3 Try the beanbag in different places, as needed.
- 4 Notice and record observations, such as swaying, losing balance, needing to shift weight, and how the beanbag shifts or falls.



SAFETY CAUTION!

Take care when moving backward or moving quickly. Make sure you move in the same direction as the rest of the class.

Communicate



1. What happened when you moved the beanbag?
2. For each animal, draw the shape that its points of contact form on the ground. How do you think this shape helps the animal stay stable?
3. Which animal walk is the most stable? The least stable? Discuss your ideas.
4. Are you more stable when you place your feet together or apart? Explain your answer.

7

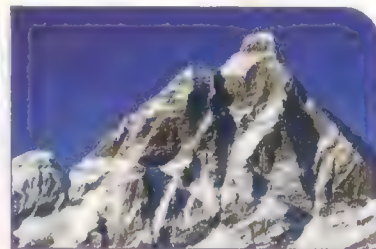
Is It a Solid, Frame, or Shell Structure?

Goal To investigate and sort different types of structures

Get Started ▶

Nature creates strong and stable structures. Sometimes humans build structures that are shaped like nature's structures. These shapes can be a solid like a mountain, a frame like a skeleton, or a shell like a nutshell.

- ▶ A sandcastle is a solid structure like a mountain.



- ▶ The net on this lacrosse stick is a frame structure like the stem, midrib, and veins of a leaf. The net helps lacrosse players catch a ball.



- ▶ A quinzhee is a shell structure like a nutshell.



Solid structures are not hollow. They are the same throughout and are usually made of one material.

Frame structures are made of firm parts that are fastened together. **Shell structures** are hollow with hard outer cases that hold the structure together. But, whether a structure is a solid, a frame, or a shell, it holds a load.

Work On It



Look at pictures of structures. What types of structures do you see? What types of loads do they hold?

What You Will Do

- 1 On a piece of paper, write the headings *Solid*, *Frame*, and *Shell*.
- 2 Look at the pictures of different structures. Decide what type of structure each picture shows. Write the name of the structure under the correct heading.
- 3 Decide what type of load each structure might carry. Write this next to the name of the structure.
- 4 Compare your work with others in your class.
- 5 Cut out pictures of structures from the magazines or catalogues. Sort them into three groups: solid structures, frame structures, and shell structures.
- 6 Share your findings with the class.

What You Need

- pictures of structures
- magazines or catalogues
- scissors



SAFETY CAUTION!

Remember to work safely when using scissors.



Communicate

1. What is the same about the structures in the pictures?
2. What is different about the structures?
3. What characteristics did you look for to sort the pictures into each group? Discuss your answer with the class.

8

How Are Materials Joined Together?

Goal To explore how materials can be joined together

Get Started ▶

Materials can be joined together with fasteners.

Fasteners are objects that fix or hold materials together. In your classroom, you use glue, string, staples, and tape to hold materials together. Nails, screws, zippers, and Velcro™ are also fasteners.

Look at the building materials and fasteners in the picture below. Discuss which fasteners you could use to join each type of material together.

Building Materials



Fasteners



First Nations peoples made natural glues from animal bones. Elders speak of a strong glue made from moose bones and a flexible glue made from rabbit bones.

Work On It

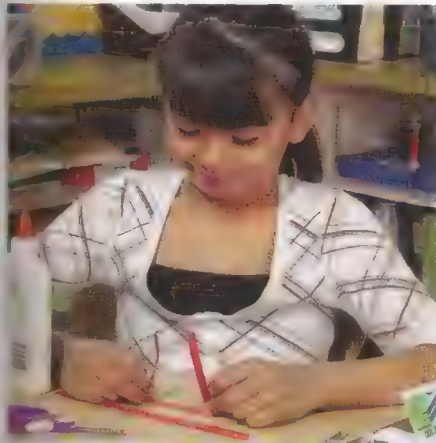
How well do fasteners hold paper together? Use your own strength to test how well different fasteners work.

What You Will Do

- 1 Cut the file folder into strips 12 mm wide, as in the photo.



- 2 Fold one strip into a U shape. Do the same with another strip.



What You Need

- file folder
- glue, tape, stapler, paper fasteners, and paper clips
- ruler
- scissors



SAFETY CAUTION!

Remember to work safely when using scissors.

- 3 Put a bit of glue at the bottom of the U. Stick that part of the strip to the same part of the other strip. Let the glue dry.
- 4 Repeat steps 2 and 3 with four other fasteners.
- 5 Test each fastener. Hold the ends of one strip in one hand and the ends of the other strip in the other hand. Pull until you break the bond. Record what happens.
- 6 For each fastener, make a list of positive and negative points.

Communicate

1. When would you use each type of fastener?
2. Look around your classroom. Find five structures and list the materials and fasteners in each.

Build On What You Know

What fasteners can you use to join materials in the bridge you will build? Make a list of your ideas.

9

What Makes a Structure Last?

Goal To find out what makes a structure last

Get Started ▶

You have learned a lot about structures. Materials can make a structure strong. The way materials are joined together can also make a structure strong.

Building structures with strong materials and fasteners helps make them last. Structures made to last are called permanent structures. Structures not made to last are called temporary structures.

Look at the structures in the photos below. They have lasted hundreds of years. Why do people build structures like these? How are the structures the same? How are they different?

- ▶ The Taj Mahal was built in India more than 350 years ago. The emperor had it made out of marble in memory of his third wife.



- ▶ Angkor Wat was built in Cambodia about 900 years ago. It was made out of sandstone as a temple for the king.



Work On It



The photos on the right show structures in Saskatchewan and around the world. Do you think these structures will last as long as those on the previous page?

What You Need

- pictures of structures

What You Will Do

1. Make a table like the one below.

Permanent	Temporary

2. Look at the pictures of structures. What materials are the structures made of? Write the names of the structures that will last in the *Permanent* column and those that will not in the *Temporary* column.
3. Compare your work with others in your class.



This round tent in Mongolia is called a yurt.



This brick house is found in Saskatchewan.



This straw hut is found in Ethiopia.

Communicate



1. What are many permanent structures made of?
2. What do temporary structures have in common?
3. Why do you think Saskatchewan's First Nations and Métis peoples built structures with cloth, wood, and sod but not rock? Discuss your answer.

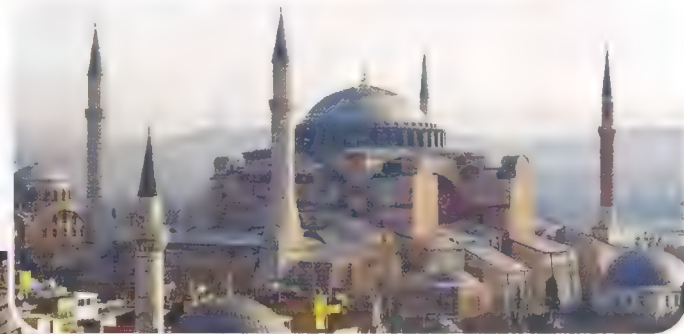
Earthquake-Proof Structures

Goal To design and build a lasting structure

Get Started ▶

Look at the structure in the photo below. It was built in Turkey thousands of years ago and has stayed standing through many powerful earthquakes.

- ▶ The Hagia Sophia was built as a large church, or cathedral. It is famous for its huge dome.



- ▲ In 1999, an earthquake damaged many buildings in the town of Adapazari in Turkey.

The photo on the left shows a town in Turkey after a large earthquake hit in 1999. Many of its buildings fell apart as the ground shook during the earthquake.

To build earthquake-proof structures, engineers must ask questions such as: What is the structure's job? What are the best materials for the job? What shapes and fasteners will hold them together when the ground shakes?



The Hagia Sophia was the largest cathedral in the world for nearly 1000 years. Today, it is a museum.

Work On It



Can you design an earthquake-proof tower? You will build a tower that has three floors and stands at least 30 cm tall. Then you will test it on a shake table to see if it stays standing without falling apart.

What You Need

- Bristol board (15 cm by 20 cm)
- ruler
- scissors
- glue, tape, paper fasteners, stapler
- marbles in box lid
- lightweight cardboard (about 20 cm by 30 cm)
- modelling clay

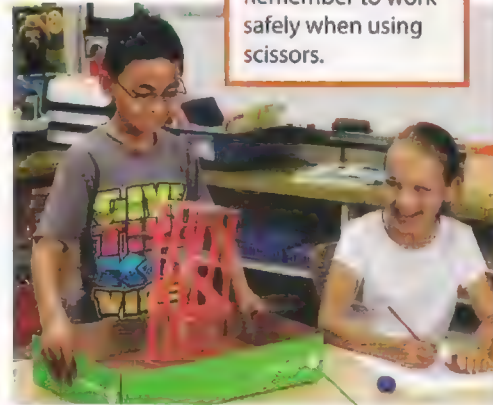
What You Will Do

- 1 Cut four squares about 10 cm by 10 cm from the Bristol board for the floors of your tower.
- 2 Cut 12 strips 10 cm long by 2 cm wide for the upright columns.
- 3 Cut 12 strips 15 cm long by 2 cm wide for the horizontal support beams.
- 4 Sketch the tower you will build.
- 5 Build your tower. Then put the cardboard on the marbles in the box lid to make a shake table to test it, as in the photo.
- 6 Use modelling clay to fasten the tower to the shake table. Slowly increase the shaking until your tower starts to sway.
- 7 How can you make your tower stand longer? Change your design as needed.



SAFETY CAUTION!

Remember to work safely when using scissors.



Communicate

1. Explain how you built your tower. Draw the steps in your notebook.
2. Label the parts of your tower. Write down what each part is for.
3. List any materials or parts of your tower that failed. Explain why you think these parts failed.

A tower that sways a bit, but does not fall apart, is well built.

Looking at Materials

Goal To find out what materials are recyclable, renewable, and reusable

Get Started ▶



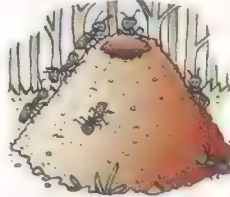
Nature is a master builder! Look at the wasp nest in the photo below. It is strong, light, and waterproof. It is also easy to make larger as needed. The building materials are easy to find and recycle, or use again.

Wasps build nests with a paper-like material made of chewed plants and wasp saliva.

Look at the structures in the pictures below. Some are made from natural materials, such as wood. Others are made from human-made materials, such as plastic.



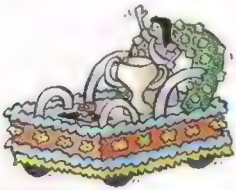
beaver dam



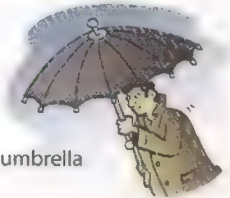
ant hill



house



circus float



umbrella



ladder



wigwam



pop can



puck

▲ All these structures are built to be very strong.

Some of these materials are **recyclable**. This means they can be made into new products. Others are **renewable**, because they can be replaced by new growth. Still others are **reusable**, because they can be used more than once.



Craik, Saskatchewan, has an eco-centre built out of straw bales and recycled materials.

Work On It



What types of materials are the structures shown on the opposite page made of?

1 Make a table like the one below.

Structure	Made From?	Strengthened By?	Reusable?	Recyclable?	Renewable?

2 Look at the pictures of each structure. Fill in the table based on what you see and what you know.

3 Compare your work with others in your class. Add any information you are missing.

Communicate



- Choose one structure made from natural material and one from human-made material. How is each material well suited for the structure?
 - What could happen if we use too much renewable material? Non-renewable material?
 - Research beaver dams, houses, and wigwams. Look for answers to the questions in the margin. Share your findings with the class.
- What materials is the structure made of?
 - How do they suit the structure's job?
 - Are they used with little waste?
 - How might building the structure affect the environment?

Lesson 12

Reusing and Recycling Materials

Goal To use materials in ways that respect nature

Get Started ▶

Materials that we take from nature are called **raw materials**. We change, or alter, raw materials so they can be used for building structures. Some structures are made from new materials like these. Others are made entirely or partly from recycled materials.

Potash is a rock found in Saskatchewan. We use this raw material to make soap, glass, and fertilizer, which helps plants grow.



Glass is often made into bottles. Glass bottles can be reused. They can also be recycled to make new glass.



When we build structures with reusable and recycled materials, we use fewer raw materials. This saves natural resources and habitats, or places where plants and animals live.

When First Nations and Métis people take something from nature, they give something back. They offer a gift of tobacco or food. This shows they are grateful, respect nature, and know that they depend on Mother Earth to survive. This also shows they understand that they must live in balance with Mother Earth.

First Nations and Métis peoples understand that nature's resources need to be available for the next seven generations of people. They understand it is important not to take more than they need.

Work On It



You will build a bird feeder from reusable and recycled materials found at home or in your classroom.

What You Will Do

- 1 Cut a hole in the milk carton, as in the photo. Make sure the hole is big enough for small birds to reach seeds inside, but small enough so the seeds do not fall out or get wet if it rains.
- 2 Use the nail to make an opening below the hole.
- 3 Insert the craft stick or twig in the hole, as in the photo. This will be the perch for the birds.
- 4 Use the nail to punch two holes at the top of the carton, one on each side.
- 5 Thread a wire or strong string through each hole and twist or tie it together at the top. This will be the hanger for your feeder.
- 6 Fill your feeder with birdseed and hang it outside.

What You Need

- clean milk or juice carton
- nail
- craft stick or twig
- wire or string
- birdseed
- scissors



SAFETY CAUTION!

Remember to work safely when using sharp objects.



Communicate

1. What other materials could you use to build a bird feeder?
2. How can you decide if a material is suitable for recycling?
3. How can you decide if a recycled material is suitable for building structures?
4. What recycled materials are used to build structures in Saskatchewan? Research your answer to this question. Share your findings with your classmates.

Well Built or Not?

Goal To find out how shape can give a structure strength and stability

Get Started ►

Keenan's family stopped at Wanuskewin Heritage Park, north of Saskatoon. The park shows the way of life of First Nations peoples who first lived in the area.

Keenan took part in a tipi raising at the park. He learned how the Cree and other First Nations used to set up their homes. He noticed that the sides of the tipi were shaped like triangles—just like the triangles he had seen in bridges, spruce trees, and other structures.



Each pole in a tipi has a meaning. Meanings vary among First Nations and Métis groups.

► A dotted yellow line marks one side of the tipi.



Work On It

Triangles are the simplest stable shape. Making a tipi will help you find out about shape and stability. **Stability** means being stable. An object that has stability will not fall over.



What You Need

- 15 twigs 25 to 30 cm long
- string about 40 cm long
- scrap Bristol board
- ruler
- scissors
- 3 brown paper lunch bags
- tape or glue

What You Will Do

- 1 Lay three twigs so they cross at one end. Tie the string around them, as in the photo.



- 2 Stand the twigs so the ends form a triangle. Add the rest of the twigs—four on each side. Tie the leftover string around them.
- 3 Make a template for the tipi cover. On the Bristol board, draw a triangle with a base as wide as the distance between two twigs. Make its height as tall as a twig from the bottom to the string at the top. Cut out your triangle template.
- 4 Open the lunch bags by cutting along the seams.



SAFETY CAUTION!

Remember to work safely when using scissors.

- 5 Lay your template on an opened bag. Trace it five times in a row, as in the photo. Cut out the shape.
- 6 Repeat step 5 to make two more shapes, one for each side of the tipi.
- 7 Fold the paper along the edges of the shapes. Tape or glue the edges together. Cut off the top so the twigs fit through.
- 8 Tape the cover to a pole. Wrap it over the rest of the poles. Seal it with tape.

Communicate



1. How does shape give a tipi strength and stability?
2. What makes a tipi a well-built structure?
3. Research the meaning of each pole for one First Nations group. (See your teacher for help.) Share your findings with the class.